E-119/C-92-318 ORDER IMPLEMENTING VOLTAGE REDUCTION PLAN AND REQUIRING FURTHER TESTING AND FILINGS

BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

Don Storm	Chair
Tom Burton	Commissioner
Marshall Johnson	Commissioner
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In the Matter of the Complaint Against Lake Region Cooperative Electric Association

ISSUE DATE: February 22, 1994

DOCKET NO. E-119/C-92-318

ORDER IMPLEMENTING VOLTAGE REDUCTION PLAN AND REQUIRING FURTHER TESTING AND FILINGS

PROCEDURAL HISTORY

I. Proceedings to Date[1]

A. Background

On April 16, 1992, the Commission received a formal complaint signed by 57 members of Lake Region Cooperative Electric Association (Lake Region or the Cooperative). The filing expressed dissatisfaction with Lake Region's response to complaints about stray voltage on dairy farms served by the Cooperative.

On May 27, 1992, the Commission met to consider requiring an answer to the Complaint. The Commission issued an Order on June 4, 1992, requiring the Cooperative to file an answer. Lake Region filed its answer on June 25, 1992. The Cooperative also filed a petition to dismiss the complaint or, in the alternative, to make the Complaint more definite and certain as to the allegations contained therein.

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[1] In this Order, the Commission reviews 1) information from the second electrical testing at Complainants' farms and 2) data submitted regarding the Complainants' herds. The Commission then considers what action it should take, if any, regarding the Cooperative's Voltage Reduction Plan (VRP) and the issues raised in the original Complaint. The Procedural History section, therefore, will not be exhaustive of all filings made in this extensive matter, but will present the major filings relevant to this Order.

On October 1, 1992, a pre-hearing conference was held to clarify issues in the Complaint and discuss procedural issues related to the Commission's consideration of the Complaint. Lake Region, the Complainants, the Department, Commission staff and Commission counsel participated in the conference. The conference served to clarify aspects of the Complaint.

On October 22, 1992, Lake Region filed an amended answer to the Complaint based on the pre-hearing conference. The amended answer included the Cooperative's proposed agreements offered to the Complainants. On October 29, 1992, the Complainants submitted comments addressing the Cooperative's amended answer.

On November 17, 1992, the Commission issued its ORDER INITIATING INVESTIGATION. In this Order, the Commission found that it has jurisdiction over this Complaint, denied the Cooperative's motion to dismiss the Complaint, and initiated an investigation of the electrical environments on both Complainants' farms. The Commission directed that the investigators provide the Commission with the results of their assessments no later than December 31, 1992.

B. The March 10, 1993 Order

On March 10, 1993, the Commission issued its ORDER DIRECTING CONTINUED TESTING AND INVESTIGATION in this matter. The primary purpose of this Order was to review the data gathered pursuant to the Commission's November 17, 1992 Order and determine what further action, if any, was warranted under the circumstances.

In short, the Commission found that further investigation in this matter was warranted. The Commission stated that it was not prepared on the basis of the existing record to find that the Cooperative's service standard regarding stray voltage was inadequate or that, for example, its practices relating to Complainants' concern were unreasonable or insufficient in violation of Minn. Stat. § 216B.17, subd. 1 (1992).

Accordingly, instead of ordering remedial action, the Commission decided to introduce certain changes in the electrical environments of both farms and assess the impact of those changes upon the cows' electrical environment and upon the cows themselves. Specifically, the Commission directed the Cooperative to install a spark gap isolator on the farm of each Complainant and to move the transformer pole (and its attendant primary neutral grounding) from the farmyard of each farm to a point determined by Commission Staff after consultation with the Complainants and the Cooperative.

To assess the impact of these changes, if any, upon the cows' electrical environment, the Commission directed the Cooperative to conduct on-site tests under the supervision of and pursuant to a testing protocol approved by Commission Staff.

In addition, to assess the impact of these changes upon the cows themselves, the Commission directed the Complainants to supplement the December '92 and January '93 production records already on file with monthly production reports through the end of the testing period, i.e. for the months February, March, and April 1993.

Finally, the Commission directed the Cooperative to file a plan for further reducing the voltage between the primary neutral and the earth on Complainants' farms.

The Commission stated that after the post-changes experience was reported by the Complainants and the Cooperative (and commented upon by the parties) and the Cooperative had filed its primary neutral to earth voltage reduction plan (and parties have had an opportunity to file comments upon that plan), the Commission would meet to consider the status of its investigation and determine its next steps in this matter.

C. Filings Stemming From the March 10, 1993 Order

The filings stemming directly from the March 10, 1993 Order may be grouped as follows:

1. Herd Data

On March 22, 1993, complainants Lonnie Nelson and Darrell Franze filed February '93 herd data.

On March 25, complainant Nelson filed records compiled regarding his herd by the Dairy Herd Improvement Association (DHIA) and complainant Franze filed additional herd data.

On March 31, 1993, complainants Nelson and Franze filed additional information and veterinarian letters regarding the Nelson herd.

On April 6 and 12, 1993, complainants Franze and Nelson, respectively, filed March '93 herd data.

On May 12 and 13, 1993, complainants Franze and Nelson, respectively, filed April '93 herd data.

On October 4, 1993, Complainant Franze filed information regarding changed conditions on his farm, primarily the installation of a Vulcan Ground Current Trap.

On October 6, 1993, Complainant Lonnie Nelson filed Additional Information Pertaining to Lonnie Nelson's Dairy Herd and a Letter from the Environmental Quality Board. Mr. Nelson requested that the Commission take notice of the information contained in the filing.

2. Voltage Reduction Plan

On April 26, 1993, Lake Region filed its Voltage Reduction Plan (VRP). Comments on the Cooperative's VRP were filed by the following parties: CPA on May 11, 1993; MNREA on May 11, 1993; the Department on May 11, 1993; and the complainants on May 13, 1993.

3. Second (May 24-25, 1993) Testing Results

On July 14, 1993, Lake Region filed the results from the May 24-25, 1993 testing. The testing involved several varieties of testing equipment, including BMI and WaveRider equipment.

On July 1, 1993, Commission Staff provided parties with additional data based on its review of Ramcorder computer files.

On July 6, 1993, the Cooperative made available additional BMI charts and WaveRider data from the May 24-25, 1993 testing.

On July 15, 1993, comments on the test data were filed by Lake Region, CPA and MNREA, Nelson and Franze, the Department, and TERF.

On July 20, 1993, Complainants filed a petition with the Commission requesting the Commission to reject parts of Lake Region's Comments on the results from the May 24-25 testing, to require Lake Region to refile the test data, and to subpoena records relating to the DC transmission line owned and operated by CPA and the United Power Association (UPA).

On July 26, 1993, the Commission received Reply Comments from Lake Region, the Department, the Complainants, MNREA and CPA on the May 24-25, 1993 test results. On July 27, 1993, TERF filed its Reply comments.

On August 2, 1993, Lake Region filed a Reply and Objection to the Complainants' July 20, 1993 petition.

On August 27, 1993, the Department filed comments on the Complainants' Petition to reject Lake Region's comments on the testing results.

On September 17, 1993, CPA filed a Report on Electrical Cooperative Sponsored Stray Voltage Research. CPA also filed a response to the Complainants' request that the Commission subpoena its DC transmission line records. The Response included data on the transmission of electricity over the CPA/UPA DC line for a time period of August 1992 through July 1993, covering both testing phases of the Commission's investigation of this matter.

On October 4, 1993, Complainant Darrell Franze filed a Notice of the Changes Which Have Occurred on the Franze Farm. Complainant Franze reported that he had hired an independent stray voltage research group called Vulcan Engineering to do ground current

testing on his farm. Mr. Franze stated that a considerable amount of electricity was found flowing into the farm yard. A Ground Current Trap was installed on the Franze farm. Complainants indicated that retesting evidenced a significant reduction in the readings. Mr. Franze reported that a second trap was later installed on the Franze farm and that additional testing indicated further reductions in the readings.

On January 14, 1994, the Commission met to consider this matter.

FINDINGS AND CONCLUSIONS

I. Overview

In this Order, the Commission reviews

- information from the second electrical testing at Complainants' farms (pages 5-13);
- data submitted regarding the Complainants' herds (pages 13-17);
- the Cooperative's Voltage Reduction Plan (pages 17-20); and
- the emergence of the Vulcan Trap (page 20).

Following that review, the Order will present the Commission's

- analysis (pages 22-25) and
- action (pages 25-26).

II. Second Electrical Testing at Complainants' Farms

On May 24-25, 1993, a second round of testing was conducted by Lake Region under Commission Staff supervision at both of the Complainants' farms. The protocol for the second test was developed by Commission Staff with input from the parties. The second protocol was designed similar to the first protocol to allow comparison of the data.

A. Electrical Testing at the Franze Farm

1. Lake Region's Comments on the Electrical Testing at the Franze Farm

Lake Region's comments on the test data focused on six issues. These issues are as follows:

- Were there any unacceptable levels of contact voltages found on the complainants farms?

Lake Region stated that the May testing produced no problematic contact voltages on either farm. Mr. Franze's highest contact voltage is reported at .07 volts.

- Does the testing show any correlation between DC voltage levels and the wiring configurations during testing?

According to Lake Region, the DC values as reported are independent of any particular wiring system. The Cooperative stated that the highest contact voltage value recorded on the Franze farm is .32 volts from waterline to rear hooves. It also noted that the DC voltage always remained below .5 volts in both the December and May testing on both farms.

- Was the waterline to reference voltage within accepted standards?

Lake Region indicated again that the generally accepted standard in the industry is that there is no perception below .5 volts and no adverse effects below 1 volt across two contact points. This standard presumes measurements made using a 500 ohm resistor and steady state conditions. The Cooperative points out that this measurement (waterline to reference) is not a contact point variable, and that a cow could never come in contact with voltages measured under these test conditions. This data point has only diagnostic significance. The values measured on the Franze farm were at or below the WaveRider threshold. Only during an impedance test did the values reach .6 volts at the Franze farm.

Lake Region concluded that the voltage which did appear on the waterline was below the industry accepted standard of .5 volts and that transients were either non existent or of low levels. The Cooperative stated that this measurement does not impact the electrical environment of the dairy cow.

- Did the equipment used provide the same data reference as the equipment used in the December testing?

Lake Region discussed the use of the BMI recording device indicating that it is a sophisticated instrument usually not necessary for stray voltage investigations. They indicate that stray voltage testing procedures should focus on steady state values or transients which contain enough energy to be of concern. The Cooperative indicated that channel 3 can be used for diagnostic purposes only as it was not an animal contact point measurement. It also stated that all the printouts that indicate "low frequency" are not relevant for grounding systems or metallic objects.

Lake Region further stated that all animal contact voltages are less than .1 volts except for the open circuit conditions which have no animal load resistance involved. These were still below .52 volts.

- What effect does primary neutral voltage and secondary neutral voltage measurements have on the electrical environment of the dairy cows?

Lake Region stated that the primary neutral voltage reached 8.5 volts at the Franze farm. The Cooperative asserted that ten volts is an acceptable level of primary neutral voltage. It stated that at the Franze farm there is some influence of the primary ground on the secondary ground at the transformer pole and noted that spikes occurring on the primary side did not correspond with spikes on the secondary side.

Lake Region noted that secondary voltage at the transformer pole ranged up to .6 volts on the Franze farm. The Cooperative stated that this happened under conditions of high unbalanced loading on the on-farm wiring system. It argued that even though barn panel secondary voltage to ground ranged up to .13 volts at the Franze farm, this voltage is below an attainable level of .35 volts recommended by the University of Minnesota.

- Were the cow reactions during the testing period unusual or reflect any effects from the cow electrical environment?

In posing this question as part of its comments on the electrical testing, Lake Region exceeded the clearly defined scope of the testing. Submission of opinions in response to its self-initiated question were likewise not authorized. Lake Region had as an observer of the testing Dr. George Marx from the University of Minnesota, Crookston. Dr. Marx's presence at the testing was authorized by the testing protocol as a witness to the conduct of the test. In conjunction with its comments regarding the electrical testing, however, the Cooperative submitted observations of herd behavior made by Dr. Marx in the course of the testing. Assessment of herd behavior and herd management practices was clearly beyond the scope of the electrical test protocol. Accordingly, the Commission will not consider Dr. Marx's comments on that subject.

Lake Region's Conclusion Regarding Electrical Testing: Lake Region concluded that the investigation has determined that there are no levels of traditional stray voltage found on these two farms and that the electrical environment has been investigated enough.

2. Nelson and Franze Comments on the Electrical Testing at the Franze Farm

The Complainants filed joint comments directed to two primary subjects: test procedures and test data.

- Complainants' Comments on Test Procedures

The Complainants stated that the test protocol should have established a 24 hour monitoring period. They suggested that a better event log should have been kept. They stated that the log appears to focus on sources located on the farm. In addition, the Complainants asserted that substation outages occurred during the December and May tests. They suggested that these outages could cause electrical changes on their farms.

The Complainants underlined that the existence of current flowing through their property after disconnection of grounds at the two farms is what has given the Commission an indication of where the problem exists.

Further comments regarding the protocol are that the testing should have included a second BMI device to help determine the source of transients.

- Complainants' Comments on the Franze Test Data

Primary voltage and amperage: the Complainants stated that the amperage entering the earth is too high. All control of this electricity is lost once it enters the earth.

Secondary voltages and amperages: the Complainants noted that these were greatest when the systems were bonded during the impedance test. The otherwise low readings are a result of ground coupling between primary and secondary neutrals at the transformer pole. They stated that secondary voltages from lighting on the Franze farm were not seen under normal operating conditions, as the lighting circuits are connected to opposite legs of the panel and the two circuits cancel each other out. These lighting circuits are the only 120 volt loads in the barn.

Waterline amperages: the Complainants observed that waterline amperages were around 7 milliamperes steady state during the testing and were 15 milliamperes during the impedance testing. The Complainants stated that these readings, taken with a different instrument in December were closer to 500 milliamperes.

Waterline voltage to earth reference: the Complainants stated that this was 1.5 volts during the bonded portion of impedance testing. Complainants asserted that the fact that the waterline to floor voltage was zero during the bonded system testing indicated that there is just as much electricity in the floor as in the waterline.

Phase to neutral voltages: the Complainants argued that the phase to neutral voltages measured contradict Lake Region's concerns about moving the transformer causing problematic voltage drops.

Transients: Complainants noted that the only time transients were not recorded was during a 20 minute period following disconnection of the first ground wire. Complainants concluded that the BMI data show that transients have no correlation with

on-the-farm loads. Complainants asserted that the transients recorded on the BMI in the cow environment are coming from the phase wires and must be eliminated.

DC Cow Contact: Complainants noted that DC cow contact readings were recorded at 1 volt levels throughout testing. The Complainants argued that this has one or two possible sources. Either the DC comes from ground rectification of AC currents or from the DC powerline crossing Minnesota. They request this electricity be eliminated.

Impedance Testing: Complainants stated that the farm impedance is three times lower than the system impedance of the distribution line. According to the Complainants, the increase in primary neutral voltage under isolation proves that the distribution system is using the farm as a place to bleed off electricity.

3. The Department's Comments on the Electrical Testing at the Franze Farm

In its July 15th filing, the Department made the following observations regarding the electrical testing at the Franze farm.

1) Voltages and currents in May testing are significantly reduced from December values, particularly the waterline current values, presumably due to changes made to the distribution system servicing the farm.

2) Primary neutral voltages are highly sensitive to on-farm loading. This indicates that the distribution system is in need of improvement to reduce neutral to earth voltages.

3) Step potential surges approach 1 volt AC. These are simultaneous contact potentials between two points on the ground.

On July 26, 1993, the Department filed substantial reply comments. Regarding the May electrical testing at the Franze farm, the Department stated that cow contact voltages sufficient to cause problems for the cows were recorded: a peak step potential of 2.9 volts was recorded. The Department recommended that the Commission use an independent investigator to measure step potentials, waterline to hoof, and transient voltages. If the voltages are higher than .5 vac, the Department stated that their source should be determined and they should be eliminated.

4. MNREA and CPA Comments on the Electrical Testing at the Franze Farm

MNREA and CPA filed general comments not specific to the Franze farm. They asserted that no significant cow contact potentials were recorded. They also stated that there is no evidence to support Complainants' allegations.

5. TERF Comments on the Electrical Testing at the Franze Farm

In its initial comments filed with the Commission on July 15, 1993, TERF suggested that two BMIs should have been used to conduct the testing in order to test for harmonics and record transients on the phase wires. TERF argued that it was very important to determining the source of transients.

TERF stated that the farms of both Complainants show consistently high levels of utility generated currents and transients in the barns. TERF asserted that the fluctuation in milk production and water consumption indicated that the electrical magnitudes within the cow's environment is changing.

TERF stated that the testing data provided by Lake Region is incomplete and inadequate. TERF argued that the lack of cooperation and inadequate data on the part of Lake Region requires that any future testing should be done independent of the utility.

In reply comments filed on July 27, 1993, TERF argued that Lake Region has a serious power quality problem consisting of transients and harmonics. TERF suggested that the transients measured on the farm, by the BMI, are coming from Lake Region's phase wires, and that the wave shapes recorded by the BMI are an indication of both a power quality problem and a serious harmonics problem.

TERF took issue with Lake Region's position that the 240 volt motors on the farm are the cause of the transients measured by the BMI. TERF argued that the motors on the farm are balanced, that the transients travel to the barn through earth coupling. TERF also contended that the research which Lake Region uses to support this argument does not examine transients and power quality.

B. Electrical Testing at the Nelson Farm

1. Lake Region's Comments on the Electrical Testing at the Nelson Farm

As with its comments regarding the Franze farm testing, Lake Region arranged its comments in response to six self-posed questions.

- Were there any unacceptable levels of contact voltages found on the Complainants farms?

Lake Region stated that the May testing produced no problematic contact voltages on either farm. The Cooperative noted that Mr. Nelson's highest contact voltage is reported at .1 volts.

- Does the testing show any correlation between DC voltage levels and the wiring configurations during testing?

Lake Region stated that the DC values as reported are independent of any particular wiring system. The Cooperative also stated that the highest contact voltage value recorded on the Nelson farm is .32 volts from waterline to rear hooves. It also stated that the DC voltage remained below .5 volts in both the December and May testing on both farms.

- Was the waterline to reference voltage within accepted standards?

Lake Region repeated that the generally accepted standard in the industry is no perception below .5 volts and no adverse effects below 1 volt across two contact points. This standard presumes a 500 ohm resistor and steady state conditions. The Cooperative pointed out that this measurement is not a contact point variable and that a cow could never come in contact with voltages measured under these test conditions. The Cooperative stated that this data point has only diagnostic significance. The values measured on the Nelson farm were near the WaveRider minimum threshold. Only during an impedance test did the values reach .85 volts at the Nelson farm. The Cooperative asserted that the secondary farm wiring system is contributing to voltages measured at this location.

Lake Region concluded that the voltage which appeared on the waterline was below the industry accepted standard of .5 volts and that transients were either nonexistent or of low levels. They state that this measurement does not impact the electrical environment of the dairy cow.

- Did the equipment used provide the same data reference as the equipment used in the December testing?

Lake Region discussed the use of the BMI recording device indicating that it is a sophisticated instrument usually not necessary for stray voltage investigations. They argued that stray voltage testing procedures should focus on steady state values or transients which contain enough energy to be of concern.

- What effect does primary neutral voltage and secondary neutral voltage measurements have on the electrical environment of the dairy cows?

Lake Region stated that the primary neutral voltage reached 4.6 volts at the Nelson farm. Lake Region takes the position that ten volts is an acceptable level of primary neutral voltage.

Secondary voltage at the transformer pole ranged up to .6 volts on the Nelson farm. Lake Region indicated that this happened under conditions of high unbalanced loading on the on-farm wiring system. The barn panel secondary voltage to ground ranged up to .08 volts at the Nelson farm. Lake Region indicated that the

barn panel secondary voltage is below an attainable level of .35 volts recommended by the University of Minnesota.

Lake Region's Conclusion: the Cooperative concluded that there are no adverse effects from these voltages in any cow contact voltage area of the animal environment.

- Were the cow reactions during the testing period unusual or reflect any effects from the cow electrical environment?

The Commission finds this question outside the scope of the agreed upon electrical testing protocol and will not consider the comments of Dr. Marx related to that question. See supra at page 7.

2. Complainants' Comments Regarding the Electrical Testing at the Nelson Farm

The Complainants stated that the amount of electricity entering the earth from the primary neutral at the Nelson farm is too high and must be eliminated.

The Complainants stated that the ground coupling between primary and secondary neutrals at the transformer pole makes it difficult to determine if there is an on farm contribution. They observed, however, that when the primary pole grounds were opened the current in the barn service panel secondary grounding conductor went to zero momentarily.

The Complainants asserted that the secondary voltages at the transformer pole are the result of earth coupling. The Complainants stated that the secondary neutral amperages appearing after power restoration were from refrigerators and freezers in the house. That these events did not show up on the BMI charts indicates, according to the Complainants, that these loads are not impacting the cow environment.

Waterline amperages were 7 milliamperes, contrasting with up to 500 milliamperes measured in December testing.

The Complainants observed that a cow contact voltage on the Nelson farm in excess of .5 volts shows up at a point in time before any event log was kept. This contradicts Lake Region's position that there are no problematic voltages in cow contact areas.

The Complainants noted that there are 210 points of contact between the waterline and stalls. According to the Complainants, this means that all electricity measured in the waterline to reference is also in the barn floor.

The Complainants asserted that the BMI events do not correlate with any on farm electrical use. They noted that during two separate hours on the Nelson farm, 26 impulses were recorded up to 4.6 volts, and 59 impulses up to 4.9 volts.

The Complainants noted that under conditions of constant 240 volt loading a quiet period of 23 minutes occurred following disconnection of the first pole ground. They observed another 20 minute quiet period occurred following disconnection of the second pole ground. During a five minute period when pole grounds were open and no resistors were in place, 46 impulses were recorded from waterline to reference.

The Complainants asserted that DC voltages of just under 1 volt are caused by earth rectification of AC currents or from the DC powerline crossing Minnesota.

Regarding the second pole ground amperage measurement, the Complainants asserted that the AEMC meter used at this location was limited to a 100 milliampere minimum range and should not have been used for this test.

3. The Department's Comments on the Electrical Testing at the Nelson Farm

The Department's general recommendations have been described in Franze electrical testing section above. Specifically regarding the Nelson testing, the Department made the following observations.

- Cow contact voltages waterline to hoof are in excess of 1 volt, and step potentials are at .67 volts. The Department stated that peak voltages in the step potential show transients that may be of problematic magnitude.

- December primary neutral voltages were in the range of 6-12 volts, with spikes above 16.5 volts. The Department recommended that these be lowered to below five volts.

- The Department noted that load balance on the Nelson distribution line had improved between December and May testing, rendering further load balancing at the Nelson farm unnecessary.

- The secondary neutral conductor amperage readings indicate a 8-14 ampere imbalance between the phase conductors during most of the milking period. The Department found insufficient information to agree with Complainants that ground coupling is the source of this amperage.

4. MNREA and CPA Comments on the Electrical Testing at the Nelson Farm

CPA and MNREA reviewed the results of the May 24 and 25, 1993 testing in conjunction with an analysis of the milk production, water consumption, and somatic cell count records and drew the following four conclusions.

- There are still no unacceptable levels of voltage or current of concern in the cow contact areas.

- There is no record evidence supporting Complainants' theories that utility-generated electrical flow is having an adverse impact on their herds.

- An expanded investigation of the many non-electrical variables that may affect herd health is necessary to determine the existence and cause of any problems that exist on Complainants' farms.

- The scientific community must conduct more research and testing before the Commission can evaluate the validity of Complainants' theories.

5. TERF Comments on the Electrical Testing at the Franze Farm

TERF stressed that determining the source of transients is very important and suggested that two BMIs should have been used to conduct the testing in order to test for harmonics and record transients on the phase wires.

TERF alleged that the record of the testing provided by Lake Region is incomplete and inadequate. TERF stated that the farms of both Complainants show consistently high levels of utility generated currents and transients in the barns. According to TERF, fluctuation in milk production and water consumption indicated that the electrical magnitudes within the cow's environment are changing.

TERF argued that the lack of cooperation and inadequate data on the part of Lake Region requires that any future testing should be done independent of the utility.

In reply comments filed on July 27, 1993, TERF asserted that Lake Region has a serious power quality problem consisting of transients and harmonics. TERF stated that the transients measured on the farm by the BMI are coming from Lake Region's phase wires, and that the wave shapes recorded by the BMI indicate both a power quality problem and a serious harmonics problem.

TERF objected to Lake Region's assertion that the 240 volt motors on the farm are the cause of the transients measured by the BMI. TERF claimed that the motors on the farm are balanced and that the transients travel to the barn through earth coupling. TERF also contended that the research which Lake Region used to support its argument does not examine transients and power quality.

III. Herd Data

A. The Franze Herd

1. Lake Region's Comments on the Franze Herd

In addition to Dr. Marx's site visit comments described above in Lake Region's test data comments which have been excluded from the record by the Commission as beyond the test protocol, Lake Region provided a one page letter from Dr. Marx analyzing the two herds. In his comments, Dr. Marx stated that both herds exhibit normal variations in production, cell count and water consumption. He stated that in general the Franze cell count is higher than Nelson's and that this may be due to late lactation, older cows, or more mastitis. He attached a list of fifty variables in herd management that can contribute to herd problems. After reviewing many documents Dr. Marx determined that he can find no unusual conditions, circumstances or production responses that would lead him to believe that stray voltage is a problem in these two herds.

In comments regarding the water consumption, Lake Region questioned the reliability and verifiability of the records. The Cooperative stated that the levels of water consumption on these two farms fall into the lower water consumption curve or category, but are not considered abnormal.

Lake Region further noted that because production data since the time of disconnected grounds are not available, the production data tell nothing about the standards of electrical maintenance. The Cooperative asserted that the periods of disconnected grounds were not normal conditions.

Regarding the Franze herd production in particular, Lake Region stated that this herd is performing near the state dairy herd DHIA average and is 5,000 pounds per year above non DHIA farm production levels. According to the Cooperative, the Franze herd is producing to its expected potential and that water consumption is adequate. In conclusion, the Cooperative stated that the investigative process had not looked into any analysis of nutritional or management issues that may contribute to herd problems.

2. The Complainants' Comments on the Franze Herd

Water consumption: Complainants alleged that the water consumption target should be 30-40 gallons per day per cow.

Milk production: Complainants stated that milk production now is below levels indicated by past records. This indicates, according to the Complainants, that higher production levels are capable on these two farms.

Somatic cell counts: Complainants alleged that somatic cell counts on both farms are high.

Other: In their "Petition for More Expedient and Suitable Relief" Complainants submitted a detailed summary of the herd behavior as it relates to grounding conditions.

Regarding the Franze herd in particular: the Complainants cited examples from the data relating to ground wire condition. The Complainants noted that disconnecting grounds caused a positive increase in water consumption, milk production, a decrease in somatic cell counts, and more tolerable cow behavior. The Complainants point to an increase in water consumption on December 20, 1992 from 16-25 gallons per day coincident with ground disconnection and a water consumption decrease to 9-10 gallons per day on March 14, 1993 coincident with ground reconnection.

Reply comments: the Complainants further discussed the relationship between water consumption and ground condition. The Complainants cited four specific days on which grounding conditions affected water consumption. According to the Complainants, these examples show that water consumption went up after disconnection and down upon reconnection.

3. The Department's Comments on the Franze Herd

The Department stated that the dairy herd data are insufficient to draw any meaningful conclusions. The Department stated that data needs to be gathered over a longer period of time and include at least DHIA summary sheets and milk market, milk quality data.

The Department, however, noted that water consumption data indicate the herd is at the low end of the normal range and that cell count data indicate a severe problem with udder infection (mastitis).

The Department stated that to evaluate the impacts of electrical system changes would require a herd history extending two years *prior* to the time changes were made. In addition, the Department stated, data from at least six to twelve months *after* the changes were made would be required to see long term herd impacts of these changes on the herd.

The Department listed specific parameters it recommended be monitored if cause and effect relationships were to be determined. The Department also pointed out that even if an electrical stressor is eliminated the herd may not respond if another stressor remains which is more limiting to the herd.

In its reply comments, the Department recommended a more thorough study of the herd production data. The record of production data to date did not allow a definitive analysis of the relationship between cutting grounds and herd production. The Department recommended that this study begin after the implementation of the voltage reduction plan, after further electrical investigation by an independent expert, and after elimination of any cow contact voltages over .5 volts and continue for a period of at least six months.

4. MNREA & CPA Comments on the Franze Herd

CPA and MNREA argued that the Complainants had compromised the database on the impact of primary neutral-to-earth current on herd health when they cut the grounds. Nevertheless, according to MNREA and CPA, even the data reported by the Complainants shows that primary grounding does *not* have an impact on the performance of the herd.

In sum, CPA and MNREA asserted there is no correlation between primary neutral-to-earth grounds and herd performance. These parties stated that the data are inconsistent with the allegations and theories of Complainants.

5. TERF's Comments on the Franze Herd

TERF questioned the experience of Lake Region's veterinarian as well as the accuracy of his comments. TERF contended that a meaningful conclusion on herd health is not possible without reviewing the DHIA records, nutrition, genetics and management on each farm. TERF argued that the milk production of the cows should be well over 20,000 lbs. per year herd average.

B. The Nelson Herd

1. Lake Region's Comments on the Nelson Herd

Lake Region noted that there are some cows producing over 20,000 pounds per year. According to the Cooperative's expert witness, Dr. Marx, this would preclude the possibility of traditional stray voltage problems.

Similarly, the Cooperative noted that the 54 pounds per day per cow average reported on the Nelson farm is in line with Nelson's annual rolling herd average and the production appears to have increased during the December 1992 to April 1993 reporting period.

2. The Complainants' Comments on the Nelson Herd

The general comments described in the Franze herd comments section are also applied to the Nelson herd. Specific comments on the Nelson herd relate to the distribution system balance condition. Complainants asserted that the line serving the Nelson farm was better balanced in May than in December. This corresponds to a change in production levels from 47-53 pounds per cow per day in December to 65 pounds per cow per day in May.

3. The Department's Comments on the Nelson Herd

The Department's general comments in the Franze comment section apply to the Nelson herd as well. In short, the Department stated that there is not enough information available to assess the Nelson herd production data.

The Department challenged CPA and MNREA's analysis of two days when ground condition changed on the Nelson farm. The Department noted that the time periods evaluated by CPA and MNREA were inconsistent.

Finally, the Department stated that the multidisciplinary approach to investigating non-electrical causes of herd problems suggested by MNREA and CPA was outside the Commission's authority.

4. MNREA & CPA Comments on the Nelson Herd

As it did regarding the Franze herd, CPA and MNREA argued that the database on the impact of primary neutral-to-earth current on the health of the Nelson herd had been compromised by the Complainants' cutting of the grounds, making it impossible to draw any solid conclusions. An analysis of the data available, as reported by the Complainants, shows that the grounding factor does not have an impact on the performance of the herd.

CPA and MNREA asserted there is no correlation between primary neutral-to-earth grounds and herd performance. They argued that the data are inconsistent with the statement and theories of Complainants.

5. TERF's Comments on the Nelson Herd

TERF questioned the experience of Lake Region's veterinarian as well as the accuracy of his comments. TERF contended that a meaningful conclusion on herd health is not possible without reviewing the DHIA records, nutrition, genetics and management on each farm. TERF argued that herd average milk production should be well over 20,000 lbs. per year herd average.

IV. The Cooperative's Voltage Reduction Plan (VRP)

In its March 10, 1993 ORDER DIRECTING CONTINUED TESTING AND INVESTIGATION, the Commission directed Lake Region to prepare a primary neutral-to-earth voltage reduction plan for the neutral circuit extending to the Complainants' farms. At a minimum, the plan was to include plans for load balancing, grounding improvements, reconductoring and regulator repairs. Lake Region was also required to examine the feasibility and projected efficacy of each change addressed in the plan.

1. Lake Region's Proposed VRP

On April 26, 1993, Lake Region filed its Primary Neutral-to-Earth Voltage Reduction Plan (VRP) with the Commission. The Cooperative's proposal examines various alternatives for reducing primary neutral-to- earth voltage levels. These alternatives included the following:

- voltage regulator repairs
- limiting the current drawn by the transformer at the farm site
- balancing the loads on three phase lines
- lowering the impedance of the neutral conductor and increasing the number and quality of the grounding electrodes

2. The Complainants' Comments on the VRP

On May 13, 1993, the Complainants filed comments on Lake Region's proposed VRP. The Complainants responded to each alternative outlined by Lake Region.

The Complainants argued that Lake Region's suggestion that customers limit the amount of electricity they use in order to reduce primary neutral-to-earth voltages is inappropriate and impossible to achieve. Such a proposal, the Complainants contended, confirms that Lake Region's distribution system is faulty.

Balancing Loads on Three Phase Lines

Complainants stated that variations in the type of consumer, their usage patterns, both daily and seasonally, will all effect the load balance at any particular time and date. The fact that it is difficult, if not impossible, to keep a balanced load on a three-phase distribution system supports the Complainant's contention that a different distribution system is needed.

Lowering Resistance

- Improving connections

The Complainants argued that cleaning connections and, if necessary, replacing split bolt connectors should be part of Lake Region's regular maintenance on its system. Petitioners also asserted that Lake Region has not yet performed these maintenance activities and should be ordered to perform them.

- Installing larger neutral wire

Noting Lake Region's estimate that it would cost between $12,000 and $25,000 per mile to upgrade the existing wire distribution system, the Complainants argued that the cost of changing Lake Region's distribution system to a different type would be less costly than upgrading the existing system and would be more productive.

- Increasing the number and quality of grounds

The Complainants argued that lowering the voltage on the primary neutral by increasing the number and quality of grounds only puts

more amps into the earth and would be counter-productive, intensifying their problems. The Complainants argued that removing all electricity from the earth is the heart of their complaint and have indicated that no additional grounds will be allowed in their farm yards. In sum, the Complainants objected to Lake Region using their farmland for grounding.

3. The Department's Comments Regarding the VRP

On May 11, 1993, the Department filed comments on Lake Region's VRP. The Department stated that while Lake Region had included a discussion of most of the available options for reducing primary neutral-to-earth voltage, the Cooperative's analysis of those options was inadequate. For example, the Cooperative did not examine the cost-effectiveness of the voltage reduction options from either society's or the farmer's perspective. In addition, the Department took issue with some of the calculations presented and developed from the December 1992 testing conducted on the Complainants' farms.

Finally, the Department indicated that the accuracy of the presentation, as well as some of the calculations Lake Region provided in its report on the alternatives for reducing neutral-to-earth voltage are suspect, particularly on page 5 of the Plan which illustrates the influence of primary neutral voltage and system impedance on primary neutral-to-earth voltages on the Complainants' farms.

On July 26, 1993 filed reply comments based upon the analysis of the Department's consultant, Gerald Bodman. Among its recommendations, the Department made the following two regarding the VRP:

1) The Commission should direct Lake Region to implement a VRP pursuant to which the Cooperative

- checks all neutral connections of the distribution system between the Complainants' farms and the substations serving those farms, replacing all poor quality connections;
- re-examines balancing the loads on the distribution line serving the Franze farm;
- verifies that the voltage regulators are not malfunctioning intermittently and fix them if they are; and
- improves the grounding in the vicinity of the two farms if acceptable to the farmers.

2) The Commission should use an independent investigator to measure step-potential, waterline-to-hoof and transient voltages. If these voltages are still higher than 0.5 Vac, determine their source and attempt to eliminate them.

4. Comments of CPA on Lake Region's Proposed VRP

On May 10, 1993, CPA filed comments on Lake Region's VRP. CPA recommended that the Commission assess the plan with a sensitivity to the costs and efficacy of each of the alternatives and order the implementation of any mitigation alternative only if there is sufficient evidence in the record which indicates the necessity of such mitigation.

CPA's central concern is the potential impact a Commission decision to order Lake Region to implement a mitigation alternative may have on cooperatives throughout Minnesota. The Association indicated that any Commission ordered mitigation may become a de facto policy standard for utilities on the levels to be concerned with, as well as what is the appropriate mitigation strategy.

CPA stated that the voltage reduction options discussed by Lake Region in its VRP have wide ranging financial implications for utilities. Some options, such as the installation of an isolator, have relatively small financial implications where other options, such as the reconfiguration of the utility's distribution system, have significant financial implications.

CPA deferred to Lake Region's technical analysis regarding the costs and efficacy of the various options for reducing primary neutral-to-earth voltage, but noted that costs incurred by utilities to mitigate stray voltage and/or primary neutral-to-earth voltage will be passed on to their customers. Because of the potential for significant economic impacts upon utilities, their customers, and the state as a whole, CPA urged the Commission to be cautious.

Finally, the CPA recommended that the Commission consider on-farm options. The Association argued that there are options to prevent or mitigate stray voltage problems which can be taken by the farmer.

V. The Vulcan Trap

In previous Orders, the Commission has stated that it is taking a practical, problem-solving approach in this matter. The Commission acknowledges that scientific research has not yet defined with clarity the influence of primary grounding on dairy cows nor has it indicated the most effective ways to mitigate the presence of that electrical current. The Commission takes note, however, of all initiatives being taken in this area so that it may best tailor its response.

On October 4, 1993, Complainant Darrell Franze filed a Notice of the Changes Which Have Occurred on the Franze Farm. Complainant Franze stated that he had hired an independent stray voltage research group called Vulcan Engineering to do ground current testing on his farm. Mr. Franze indicated that a considerable

amount of electricity was found flowing into the farm yard. A Vulcan Ground Current Trap (referred to in this Order as a Vulcan Trap) was installed on the Franze farm. Complainants indicated that post-installation testing evidenced a significant reduction in the readings, followed by a resurgence of ground current. A second trap was then installed on the Franze farm and Complainant Franze reported further reductions in the readings and improved herd health.

At the hearing on this matter on January 14, 1994, however, Complainant Franze reported that, coincident with the onset of severely cold weather in December '93, the traps installed on his premises appeared to lose their earlier effectiveness. Data to confirm the earlier experienced improvements in the cows' electrical environment was unavailable due to the illness of the trap's manufacturer.

Subsequent to the early success experienced at the Franze farm, Complainant Nelson installed a Vulcan Trap on his farm. Mr. Nelson reported that he noted only slight improvement following installation of a Vulcan Trap at his farm.

No data is available to assess the impact of the trap on the cows' electrical environment, production, or health on either farm. In addition, the record contains no information regarding the physical details of the trap or the principles on which it operates.

In these circumstances, the Commission finds that there is no basis in the record to conclude that deployment of the Vulcan Trap on Complainants' farms has eliminated the need for the voltage reduction measures that it has undertaken to date and further contemplates in this Order. Accordingly, the Commission will proceed with these measures.

VI. Commission Analysis

A. Electrical Testing

After reviewing the second electrical testing conducted at the Complainants' farms, the Commission notes that the steps taken to date to reduce the amount of utility sourced electricity on the two farms appear to have had some success. When compared to the readings taken in December '92, the May testing shows significantly reduced readings for waterline to reference voltages and waterline currents.

The Commission also notes two areas of concern:

1. Transient Count Concern

During the May testing at the two farms, the BMI recorded widely differing amounts of transients during different times in the test sequence. The fact that any were recorded during static 240

volt load testing when no on farm load was active and ground connections were open causes Commission concern as to the source of these impulses. The testing provides no conclusive answer to that question.

2. Contact Voltages Concern

The Department identified cow contact potentials above .5 volts on the BMI charts that they interpret as having the potential for significant herd impact. Since the time frame of the test was limited, it cannot be known from this testing how often these contact voltage spikes occur during a 24 hour period. Further testing will help clarify this issue.

B. Herd Data

A limited number of herd parameters have been reviewed in this docket: water consumption, somatic cell counts, and total milk volume. More importantly, almost no data on post wiring changes has been reviewed. While it is possible to observe short term herd impacts of changed grounding conditions in the water records, the Commission agrees with the Department that data from a much longer time-frame would be necessary before any conclusions could be drawn.

The Commission is not inclined at this time to designate the appropriate scope[2], time-frame, or protocol to assure reliability of the Complainants' herd data. The burden of proof with respect to herd impact remains where it always has in this docket, with the Complainants. As with any party before the Commission, Complainants may choose to continue to gather and present their evidence (herd data in this case) in a manner they feel best guarantees its reliability and sufficiency to meet their burden of proof.

C. Voltage Reduction Plan

The single objective of the voltage reduction plan is the control or reduction of primary neutral to earth voltage near the dairy farms in this complaint. The Commission does not currently have a universal standard of acceptable limits on this service standard issue. In lieu of such a standard, the Commission is proceeding in a practical problem solving mode taking prudent measures to reduce the possibility of harm to Complainants' property.

The types of actions suggested by Lake Region's report and by parties fall into three categories:

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[2] For example, this Order neither prohibits nor directs the Complainants to expand the herd parameters to include an examination of the large number of animal deaths and/or culling of animals reported by the Complainants at the hearings.

- maintenance type activities that the Lake Region could or should be doing at relatively low material cost such as replacing split bolt connectors, load balancing, inspecting splices, and checking grounding integrity

- facilities upgrades in the form of line reconstruction in traditional configurations such as three phase extensions and reconductoring

- suggestions for new design strategies that would be applied to the distribution system.

The record supports modifications in each of these categories to a lesser and lesser extent as the cost of the modifications increases. What will have to be decided in this case with this record is what level of modifications is warranted in these circumstances. Prudence would dictate an incremental approach to distribution system modifications because of the ever increasing cost associated with different reduction options.

The Commission will continue its practical, problem solving approach in this matter. Specifically, the Commission will require Lake Region to implement a VRP as previously described by the Department. The Cooperative will have 45 days from the date of the hearing in this matter (January 14, 1994) to report on its VRP activities.

In addition, the Commission will mandate post-implementation testing to measure the impact of the VRP changes in the barns, near the farms, and for some distance along the line. Commission Staff will develop the protocol and arrange for an independent investigator to conduct the testing. As soon as the independent investigator has formulated its findings, the Commission will make them available to the parties for comment.

D. The Limits of Current Research

The Complainants have alleged that their dairy herds have been damaged by the flow of electric current through the ground on which the cows stand. The Complainants further contend that the Respondent Lake Region is responsible for that flow and should be required to eliminate those ground currents.

The problem that the Complainants face in making their case is that most of the research done to date has been focused on the issue of dairy herd impacts via voltage across two cow contact points and its resultant through the body current flow. This through the body current flow has been shown to impact herd behavioral characteristics and production.

However, the Commission does not have available in this record, or perhaps anywhere available, enough reference material to determine what aspects of electricity beyond cow contact voltages

may influence the complex biological organism of a dairy cow. Particularly lacking is a model of a specific interactive mechanism (other than through the body current flow) between any electrical phenomenon and the biological system.[3]

E. Need for an Investigation

This case is not an isolated incident, however. Lake Region is not the only utility whose customers are troubled with stray voltage problems. Needless to say, the progress of this case would have been greatly advanced by having standard procedures to follow and service standards on the subject of stray voltage in general and ground current in particular.

Accordingly, the Commission will direct its staff to prepare a proposal for an investigation to address the issue of ground current impacts on dairy cows.

F. Future Proceedings

In the absence of a rule or statutory standard of acceptable primary neutral to earth voltage and since the potential impacts of electricity on dairy cows cannot be determined to a reasonable degree of scientific certainty to date, the Commission in this case has employed a practical, problem solving approach, a prudent-avoidance minimum cost strategy to contain and reduce potential problems. To the extent that animal exposure to any potentially harmful utility sourced electrical phenomenon can be reduced or eliminated at a reasonable cost to the utility, the Commission has moved to implement those steps. Once the Cooperative has implemented the measures directed in this Order, the Commission will again evaluate the record to determine whether further action is warranted.

VII. Summary of Commission Action

On the basis of its review and analysis of the record in this matter, the Commission will

- direct Lake Region to implement a VRP as specified in Ordering Paragraph 1 of this Order

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[3] The lack of research on the influence of ground current on dairy herds must also be troubling to Lake Region (as it is to the Commission) because it is a very difficult matter to prove with a high degree of scientific certainty that nothing but cow contact voltages influences a dairy cow. In these circumstances, the Commission encourages the utility to actively promote appropriate independent research into this issue. For its part, the Commission will seek legislation that will provide funding for this express purpose.

- direct Lake Region to report on its VRP implementation activities as specified in Ordering Paragraph 2 of this Order

- direct its Staff to develop a protocol for testing pre- and post-VPR-implementation conditions at the two farms and to arrange for an independent investigator to conduct that testing

- establish a time-frame for parties to comment regarding the findings of the independent investigator

- delay a decision on the question of who will pay for any isolators installed on the Complainants' farms

- pursue legislation that will provide for appropriate independent stray voltage research

- direct its staff to prepare a proposal for the conduct of an investigation into ground currents and stray voltage

ORDER

1. Lake Region Electrical Cooperative Association (Lake Region or the Cooperative) shall leave the currently installed isolators in place and proceed forthwith to implement a Voltage Reduction Plan (VRP). The VRP shall include the following elements:

   (1) reasonable steps identified in consultation with Commission Staff to achieve load balancing, including an inspection of the phase connections;

   (2) verification of the integrity of neutral connections and grounds on the primary distribution system between the two farms and the substations serving those farms;

   (3) increasing the number and quality of the grounds in the vicinity of, but not on, the Complainants' farms; and

   (4) verifying that the voltage regulators are not malfunctioning intermittently and fixing them if they are.

2. On or before February 28, 1994, Lake Region shall file a report on its implementation of the VRP.

3. After the independent investigator has filed its report regarding its post-VRP-implementation testing, the parties shall have 20 days to file comments on that report.

4. This Order shall become effective immediately.

BY ORDER OF THE COMMISSION

Burl W. Haar
Executive Secretary

(S E A L)